

Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/AU04/001807

International filing date: 22 December 2004 (22.12.2004)

Document type: Certified copy of priority document

Document details: Country/Office: AU
Number: 2003907188
Filing date: 24 December 2003 (24.12.2003)

Date of receipt at the International Bureau: 17 January 2005 (17.01.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)



World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse



PCT/AU04/001807

Australian Government

Patent Office
Canberra

I, LEANNE MYNOTT, MANAGER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003907188 for a patent by MICRONISERS PTY LTD as filed on 24 December 2003.

WITNESS my hand this
Thirteenth day of January 2005

A handwritten signature in dark ink, appearing to be 'LM' or 'Leanne Mynott'.

LEANNE MYNOTT
MANAGER EXAMINATION SUPPORT
AND SALES



AUSTRALIA
Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: **ACRYLIC COMPOSITIONS**

Applicant: **MICRONISERS PTY LTD and
RENO EMILIO BELTRAME**

The invention is described in the following statement:

ACRYLIC COMPOSITIONS

The present invention relates to UV stabilized acrylic compositions and in particular to acrylic based systems containing a nano zinc oxide UV stabilizer and to a method of preparing UV stabilized acrylic coatings.

Background

Aqueous acrylic emulsions and solvent-based acrylics have been used for paints, timber vanishes, adhesives and textile coatings since the early 1950's. These acrylics are usually formulated with acrylic acid, methacrylic acid, itaconic acid or other acid groups to provide special features such as shear stability, adhesion, cross-linking, water resistance, required Tg, hardness, mar-resistance, mechanical stability and other desired properties.

Uenoyama Yasuyuki in Japan (Asahi Chemical Industry Co., Ltd., Japan). Jpn. Kokai Tokkyo Koho JP 10120724 A2 12 May 1998 Heisei, JP 96-274874 17 Oct 1996 describes the method of preparation of acrylic emulsion by emulsion polymerization of radically polymerizable monomers in aqueous media in the presence of UV absorbers and/or light stabilizers, such as Tinuvin 384, and modifying with silicones during or after the polymerization. The emulsions are suitable for adhesives, paper treatment and finishes for fabrics. An enamel coating was glossy and weather- and water- resistant.

Lorah et al in USA, Patent US 2001-981350 17 Oct 2001 describes a method for preparing the composition suitable for use, when dry, as an improved elastomeric coating, caulk, sealant, fabric treatment or pressure sensitive adhesive. The composition is provided, including a predominantly acrylic aqueous emulsion polymer, the polymer having a glass transition temperature Tg from (-) 90 to 20 C, formed by the free radical polymerization of an ethylenically unsaturated nonionic acrylic monomer and 0-7.5%, (by wt. based on the total weight of the polymer), ethylenically unsaturated acid monomer in the presence of 0.01 – 1.0% tert-alkyl hydroperoxide, tert-alkyl peroxide, or tert-alkyl perester, wherein the tert-alkyl group includes 5 C atoms and, optionally, another oxidant.

Yasutoshi Kato et al in Japan, Patent No. Tokkai Hei 6-346018 describes coatings on construction materials that have a coloured decorative layer on the surface side, that are transparent to retain the effect of the wash primer and hardly affected by photodegradation. Construction materials that are equipped with these features are rich in colours and have a long life. A paint emulsion used is made up by mixing an acrylic resin emulsion with a UV screening material such as iron oxide, zinc oxide and titanium dioxide and the paint is applied on the surface of the construction material coated with a transparent resin coating layer.

Examples of industrial water based acrylic emulsions are:

Rohm & Haas: "Primal" range of water-based acrylic emulsions:

Primal AC 6501 M; Primal MV 23L0; Primal RHA 184; Primal RHA 194;

BASF: "Acronal" range of water-based acrylic emulsions:

Acronal 290 D; Acronal 250 D; Acronal 32 D;

Valchem: "Valbond" range of water-based acrylic emulsions:

Valbond HBS 2; Valbond HBS 4; Valbond 7275; Valbond 82-48 S.

There are some examples of lower acid water based acrylic resins, which have been made specifically for adhesives, such as

Rhodia: "Rhodatak"

range of pressure-sensitive water based emulsion adhesives, these acrylic emulsions are not suitable for non tacky surface coatings.

Clear coatings made with water based acrylic emulsions or solvent based acrylics have major draw backs. Ultraviolet light produces relatively rapid deterioration in the film and in many cases also in the substrate coated by the film. In order to protect the coating film and the substrate from UV degradation, a range of organic UV absorbers and HALS (Hindered Amine Light Stabilizers) have been used. Organic UV absorbers mostly absorb in the range of 190 – 320 nm and do not give protection in the 320 to 400 nm UVA - band. HALS are free radical traps, may be used alone, but are often used in conjunction with

organic UV absorbers in clear films. These products provide limited UV protection and will deactivate over time resulting in degradation of the film and substrate.

- 5 The use of physical UV - blockers such as zinc oxide of pigmentary grade (180 - 200 nm mean particle size) give protection in the region of 190 - 400 nm and in the visible band. They have been used effectively in UV absorbing acrylic composites. When zinc oxide of 180 - 200 nm particle size is mixed into an aqueous acrylic emulsion containing free acid groups, the outer part of the
10 particle reacts with the acid to produce a zinc-polyacrylate coating, which protects the zinc oxide core residue from further reaction.

However the use of pigmentary grade zinc oxide of 180 -200 nm and larger than 200 nm in aqueous acrylic emulsions (typical levels of 7 %) is limited, because it
15 produces milky or opaque films and leads to stability problems causing unwanted viscosity increases and altered rheology with poor can stability, gelling or "livering".

The discussion of documents, acts, materials, devices, articles and the like is
20 included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed in Australia before the priority date of each claim of this application.

25

Summary

Use of nano size zinc oxide (particle size below 100 nm), as UV absorber in acrylic films provide potentially better clarity films but we have found that acid
30 containing (above 0.5 g KOH / Kg of resin solids) acrylic emulsions dissolve fine zinc oxide particles with some zinc ions forming complexes with the polyacrylate. For example we found that when a commercial emulsion such as Rohm & Haas (Primal AC 6501 M), which is typical of current commercial emulsions is mixed with 2% nano size zinc oxide (35 nm) and cast as a 50 µm

film, UV absorption test showed zinc oxide had dissolved providing no UV protection.

5 We have now found that by using acrylic compositions (or monomers for preparation thereof) with exceedingly low acidity (< 0.5 g KOH / Kg of resin solids) we can mix in nano size zinc oxide dispersions (with particle size 10-100 nm, preferably 10-50 nm) to give a stable dispersion of zinc oxide for use in a range of coating applications.

10 Accordingly we provide in a first aspect of the invention an acrylic composition comprising an acrylic component selected from acrylic resins and precursors thereof and a nonparticulate zinc oxide UV absorber wherein the acidity of the acrylic composition is less than 0.5g KOH per kilogram of resin solids.

15 In a second aspect the invention provides a method of manufacture of a zinc oxide stabilized acrylic composition comprising forming an acrylic composition having an acidity of less than 0.5g KOH per kilogram of resin solids and dispersing therein a nanoparticulate zinc oxide composition. The acrylic composition may be selected from acrylic resins and acrylic resin precursors
20 such as the monomer compositions from which the acrylic resin is derived.

In a third aspect the invention provides a zinc oxide composition comprising nanoparticulate zinc oxide comprising a surface coated with an acrylic monomer.

25

In a fourth aspect the invention provides a method of forming a zinc oxide stabilizing agent for an acrylic composition comprising:

contacting the zinc oxide nanoparticles with an acrylic monomer to form a coating of the monomer on the zinc nanoparticulates;

30

polymerizing a monomer composition comprising acrylic monomer in the presence of the acrylic monomer coated zinc oxide nanoparticles to provide zinc oxide encapsulated in acrylic resin.

In a fifth embodiment the invention provides a coating composition comprising the above described acrylic composition comprising the nanoparticulate zinc oxide and optionally other additives such as surfactants, defoamers, chain transfer agents, plasticisers initiators and stabilisers.

5

Detailed Description

The invention relates to acrylic resin compositions and in particular to acrylic film forming resins and coating compositions.

10

The composition of the invention comprises nanoparticulate zinc oxide and an acrylic composition selected from the group consisting of acrylic resins and monomer compositions for preparation thereof.

15

The term acrylic is used herein in a general sense to mean resins or monomer compositions for preparation thereof where a significant fraction of the monomeric units or monomers are selected from the group consisting of acrylic and methacrylic esters. It will be understood that co-monomers such as styrene, vinyl acetate, acrylonitrile, acrylamide, n-methylol acrylamide, vinyl acetate and others may be included. In what follows we describe a number of resin compositions but it will be appreciated that the corresponding monomer composition may also be used in admixture with the nanoparticulate zinc as a precursor to such a composition.

20

25

The acrylic resin may be present in a range of forms. In one embodiment the acrylic resin is a high molecular weight thermoplastic acrylic such as acrylic resins of the type widely used as a coating for new automobiles and to a limited extent in repair and refinish of automobiles. The acrylic resin may be a thermo setting acrylic resin or non-aqueous dispersion (NAD) acrylic which is a thermosetting solution. Alternatively the acrylic may be in the form of acrylic latices which may commonly include styrene or vinyl acetate acrylic copolymer latices which are used in place of drying oils and alkyd systems.

30

In one embodiment the acrylic resin comprises hydroxy-functional thermosetting acrylics of the type widely used in baking enamels for automobile and appliance top coats, exterior can coatings and coil coatings.

- 5 Specific examples of acrylic resins are copolymers of acrylate and/or methacrylate esters of organic alcohols and other unsaturated monomers (that is having at least one double or triple bond) capable of reacting by additional polymerisation in aqueous media. The acrylate and methacrylate monomers may have alcohol portions selected from alkyl, hydroxyalkyl, alkoxyalkyl, 10 alkylaminoalkyl and dialkylaminoalkyl. Such monomers are readily available. Specific commercially available examples include methyl (meth)acrylate, ethyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate, isodecyl (meth)acrylate, lauryl (meth)acrylate, stearyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate,, 2-dimethylaminoethyl 15 (meth)acrylate, 2-t-butylaminoethyl (meth)acrylate, glycidyl (meth)acrylate, ethylene glycol di(meth)acrylate, 1,3-butylene di(meth)acrylate and trimethylolpropane tri(meth)acrylate, including their ethoxylated variants

- Specific examples of suitable co-monomers which may be present in the acrylic resin include styrene, acrylonitrile, acrylamide, N-methylol acrylamide, 20 methacrylamide vinyl esters such as vinyl acetate, vinyl ethers such as lower alkyl vinyl ethers, allyl monomers such as allyl acetate, olefins such as lower alkenes, vinyl halides and vinylidene halides such as vinyl chloride and vinylidene chloride and urethane acrylates, ethoxylated variants of these and 25 other suitable substances that copolymerise by addition polymerisation in aqueous media.

- The acrylic polymers are preferably prepared by emulsion polymerization in aqueous media by standard methods such as thermal activation or redox 30 activation. The glass transition temperature - T_g of the desired polymer may be calculated using the copolymer equation and is achieved by suitable choice and levels of reactive monomers. The acrylic compositions are in this instance water based emulsions. The emulsions are optionally stabilized by addition of

surfactants such as sodium dodecylbenzene sulphonate or alkyl/aryl ethoxylates.

5 Acrylic resins can also be prepared in non-aqueous media. When non aqueous media is used the monomers are dissolved in suitable non-aqueous solvents that are then polymerised to a desired end-point.

The organic solids content typically ranges from 10-60% but is preferably from 45-55% solid by weight.

10

The composition of the invention comprises nanoparticulate zinc oxide by which we mean zinc oxide of particle size up to 100nm. Typically the zinc oxide component comprises at least 80% by weight of particles of size in the range of from 10 to 100 nm and more preferably at least 90% by weight in the range of
15 from 10 to 50 nm.

20

It is a feature of the invention that free acid content of the acrylic composition needs to be less than 0.5 grams of potassium hydroxide (KOH) per kilogram of resin solids as measured by titration with 0.1 M KOH solution to phenolphthalein end point. Also a suitably low free (non-volatile) alkali content is preferred. The low free acid content is important to ensuring that the zinc oxide remains unreacted and an effective UV absorber. "Acid-free" is equivalent to negligible levels below 0.5 g KOH / Kg of resin solids.

25

The composition of the invention typically contains a zinc oxide loading 0.5%-50.0%, preferably 0.5%-20%, more preferably 0.5%-10% by weight on solids in acrylic polymer (resin).

30

Nano size water based zinc oxide dispersions are preferably prepared by milling with suitable surfactants or hydroxylated organic compounds to deagglomerate zinc oxide and provide a stable suspension for mixing with the acid-free acrylic emulsion. An example of a process for milling zinc oxide is described in US Patent 6083490.

When the zinc oxide is dispersed in acrylic monomer and added to the monomer pre-emulsion, an encapsulated form of zinc oxide is provided. This can then be polymerized as above to produce an aqueous emulsion acrylic polymer having encapsulated Zinc Oxide particles in situ.

5

The compositions of the invention are particularly suited to use in clear coatings. When these dispersions are formulated into clear coatings, they provide extended UV protection to both the films and substrates (UV absorption up to 385 nm), reducing the degradation or fading due to UV, whilst providing excellent clarity and good adhesion to substrates.

10

The use of HALS to trap free radicals in the film, in conjunction with the zinc oxide, may further enhance the durability of the film and is preferred.

15

We have found that we can have levels of 1% to 50% of the 10 -100 nm zinc oxide, preferably 10--50 nm zinc oxide, mixed in suspension and added at 1-10% to the solids in the acrylic emulsion or solution and coated to a dry film thickness of 10 micron to 200 micron onto textiles, leather or timber, yet still maintain a clear film which offers greatly improved UV protection.

20

The acrylic composition of the invention may be prepared by mixing the particulate zinc oxide with an acrylic component. More preferably the composition is prepared by mixing an aqueous dispersion of zinc oxide with the acrylic emulsion or mixtures of different emulsions under low shear conditions.

25

By adjusting the range of levels of zinc oxide in acrylic emulsion we can produce dispersions of zinc oxide, which does not re-agglomerate and give good UV absorption. Optionally, rheology modifiers and coating aids can be added to the acrylic polymer (resin), provided that these are compatible with the coating and that they do not contain strong acids or alkalis that can adversely react with the metal oxide.

30

The invention includes in a preferred embodiment coating the zinc oxide particles with a suitable acrylic monomer prior to polymerization. Subsequent polymerization results in zinc oxide nanoparticles encapsulated in acrylic resin.

The coated zinc oxide dispersed which is preferably in the form of an acrylic emulsion is protected from other acid sources or additions and can then be mixed with conventional acid containing commercial emulsions.

- 5 The compositions of the invention have a wide range of applications. Examples of applications include architectural coatings for wood including paints, varnishes, stains and clear sealers; architectural coatings for other substrates such as plaster, concrete, brick and metal; appliance finishes, automotive finishes, coil coatings, can coatings, marine coatings aircraft finishes, paper
10 coatings; adhesives including pressure sensitive adhesives; caulks and sealants, water resistance agents, overprint varnishes and polishes for shoes, floors and furniture, including leather.

The discussion of documents, acts, materials, devices, articles and the like is
15 included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed in Australia before the priority date of each claim of this application.

20

The invention will now be described with reference to the following examples. It is to be understood that the examples are provided by way of illustration of the invention and that they are in no way limiting to the scope of the invention.

25 **Examples**

Methods

Aspects of the examples of the invention are discussed in Examples 1 to 10
30 with reference to attached drawings.

In the drawings:

35

Figure 1

UV-Visible absorbance profiles of samples with dry film thickness ~ 50 µm, resin – soft –4 mixed with water based dispersion of ZnO with the particle size – 30 nm

5

Figure 2

Colour difference of fabric samples at varying days of UV exposure, resin – soft –4 mixed with water based dispersion of ZnO with the particle size – 30 nm

10 Figure 3

UV –visible absorbance profiles of samples, resin –soft, mixed with water based dispersion of ZnO with particle size – 30 nm, Sanduvor 3225 – a mixture of UV absorber and HALS, and Tinuvin 5151 – a mixture of UV absorber and HALS

15 **Example 1**

Method of polymerization using REDOX conditions – soft acrylic polymer emulsion in water– acid free.

20 **EQUIPMENT:** Glass-lined reactor fitted with a variable speed stainless steel stirrer; hot water heating and cold water cooling; reflux condenser; peristaltic pumps; sample port and three delivery ports for supply of liquid streams; auto temperature measurement and controls; monomer pre-emulsion weigh tank and stirrer; catalyst feed tanks and stirrers; nitrogen gas supply; water-phase tank and stirrer.

25

PREPARATION OF PRE-EMULSION: Hot deionised water (111 g) was loaded into the water-phase tank. Rhodocal DS 10 (7.460 g) and Antarox CO8805.124 (7.320 g) were added and dissolved. To the monomer pre-emulsion weigh tank were added Ebecryl 160 (0.490 g), methyl methacrylate (44.610 g), acrylonitrile (73.000 g), N-methylol acrylamide 48% solution (25.110 g), 2-ethylhexyl acrylate (179.000 g), butyl acrylate (179.000 g). The stirrer was set on high and the solution from the water-phase tank was added over 5 minutes to produce a stable monomer pre-emulsion which was then sparged with nitrogen gas for 10 minutes. The reactor was charged with deionised water

30

(268.000 g), ferric ammonium sulphate (0.002 g), sodium bicarbonate (1.000 g). The stirrer was set to 40 rpm and the solution was sparged with nitrogen for 10 minutes whilst heating the solution (65°C). Deionised water (34.000 g) was added to one catalyst feed tank followed by ammonium persulphate (1.100 g) and dissolved under stirring with nitrogen sparge. This is the catalyst solution. To the second catalyst feed tank, deionised water (34.000 g) was added followed by sodium formaldehyde sulfoxylate (1.100 g) and dissolved under stirring with nitrogen sparge. This is the reducer solution. Monomer pre-emulsion (62.700 g) was transferred to the reactor followed by catalyst solution (3.510 g total) and reducer solution (3.510 g total) added alternately in three equal aliquots. After initiation and evidence of exotherm (reactor temperature rise), the balance of the monomer pre-emulsion, catalyst solution and reducer solution are uniformly added over 240 minutes, maintaining 65°C. At the end of all additions, the resultant polymer is held at 65°C for 1 hour then cooled to 50°C where final adjustments are made for total solids (water) and pH (ammonia 0.400 g), then cooled to ambient and filtered (100 micron).

PHYSICAL CHARACTERISTICS:

Appearance:	Milky white aqueous emulsion
Total solids content (105°C; 1 hour):	45 to 55% (typical 50%)
pH:	7 to 9 (typical 7.5)
Viscosity (cPs):	< 1000 (typical 200 to 600)
Tg (calc):	- 30°C
The polymer emulsion is stable to shear and cast films are clear, soft and relatively tack-free.	

Example 2

Method of polymerization using REDOX conditions - medium hardness acrylic polymer emulsion in water – acid free

As per example 1 – except that the ratios of monomers used to produce the final Tg of the polymer was changed. Specifically methyl methacrylate (228.000 g); 2-ethylhexyl acrylate (87.300 g) and butyl acrylate (87.300 g) were used.

PHYSICAL CHARACTERISTICS:

	Appearance:	Milky white aqueous emulsion
	Total solids content (105°C; 1 hour):	45 to 55% (typical 50%)
5	pH:	7 to 9 (typical 7.5)
	Viscosity (cPs):	< 1000 (typical 200 to 600)
	Tg (calc):	+ 19°C

10 The polymer emulsion is stable to shear and cast films are clear, tough flexible and tack-free.

Example 3

Method of polymerization using REDOX conditions - hard acrylic polymer emulsion in water – acid free

15

As per examples 1 and 2, the levels of methyl methacrylate were adjusted at the expense of 2-ethylhexyl acrylate and butyl acrylate.

PHYSICAL CHARACTERISTICS:

20	Appearance:	Milky white aqueous emulsion
	Total solids content (105°C; 1 hour):	45 to 55% (typical 50%)
	pH:	7 to 9 (typical 7.5)
	Viscosity (cPs):	< 1000 (typical 200 to 600)
	Tg (calc):	45°C

25

The polymer emulsion is stable to shear and cast films are clear, tough and tack-free.

30 Aqueous acrylic polymers similar to the above examples were produced with lower and also higher Tg values also using other surfactants and other monomers and catalysts.

Example 4

Method of polymerization using thermal conditions – soft acrylic polymer emulsion in water - acid free

As per example 1 above, except that the reducer solution was not used. The
 5 reaction was conducted at higher temperature (80 to 95°C) sufficient to ensure the activation of the catalyst.

Physical characteristics were very similar to example 1 except that the cast film had a slightly higher tack.

10 Example 5

Method of polymerization using thermal conditions – medium hardness acrylic polymer emulsion in water - acid free

The monomer ratios were maintained as per example 2.

15 The method used was as per example 4.

Physical characteristics were similar to example 2.

Example 6

**Method of polymerization using thermal conditions – hard acrylic polymer
 20 emulsion in water - acid free**

The monomer ratios were maintained as per example 3.

The method used was as per example 4.

Physical characteristics were similar to example 3.

25

Example 7

Method of polymerization using REDOX conditions – medium hardness acrylic polymer solution– acid free.

As per example 2 except that non-aqueous solvent (s) such as Isopropyl
 30 alcohol or Methyl isobutyl ketone or Toluene or other suitable solvents and their blends were used. Non-ionic surfactants were optionally used if required. Anionic surfactants were omitted. Redox catalysts were selected from those suitable for the solvent of choice such as Ditertiarybutyl peroxide or perbenzoate, Ascorbic acid and glucose but not restricted to these examples.

The reactor was set up for reflux conditions and any water produced was removed.

PHYSICAL CHARACTERISTICS:

5	Appearance:	Clear pale straw coloured liquid
	Total solids content (105°C; 1 hour):	40 to 60% (typical 50%)
	pH:	n/a
	Viscosity (cPs):	< 3000 (typical 1000)
	Tg (calc):	+ 19°C

10

The polymer solution is stable to shear and cast films are clear, tough flexible and low tack.

Similar variants were also produced with various Tg ranging similarly to examples 1 and 3.

15

Similar acrylic solutions were also produced using a thermal method.

Example 8

Predispersion of zinc oxide in aqueous media for post dispersion in acrylic emulsion

20

Nano size zinc oxide was dispersed in water in a Hockmeyer mill 2 L (bead mill), beads used were 0.4-0.7 mm Jyoti.

25 Nano size zinc oxide (900 g), Orotan 731 DP (162 g), Teric N20 (12 gm), Teric N40 (12 g), propylene glycol (81 g), water (840 g), antifoam (23 g) were mixed together with a blade mixer to form even mixture, then loaded into Hockmeyer mill and milled for six hours.

Example 9

Predispersion of zinc oxide in aqueous media for post dispersion in acrylic emulsion

30

The experiment in example 7 was repeated on 1/33.33 scale in 40 L capacity Hockmeyer mill, beads used 0.4-0.7 mm Jyoti.

Example 10

ZnO dispersion in monomer to enable encapsulation of zinc oxide particles in polymer (method as per example 1 - zinc oxide dispersion added with 2EHA to premonomer phase)

5

Nano size zinc oxide (810 g) and monomer 2 ethylhexyl acrylate (430 g) were mixed together in a z-arm mixer for two hours, then Solsperse 21000 (12 g) was added gradually and mixed for one more hour.

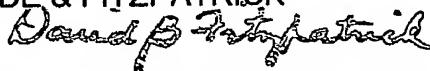
- 10 Finally, it is understood that various other modifications and/or alterations may be made without departing from the spirit of the present invention as outlined herein.

DATED: 24 December, 2003

15

PHILLIPS ORMONDE & FITZPATRICK

Attorneys for:



MICRONISERS PTY LTD AND RENO EMILIO BELTRAME

Absorbance of Different ZnO Particle Sizes

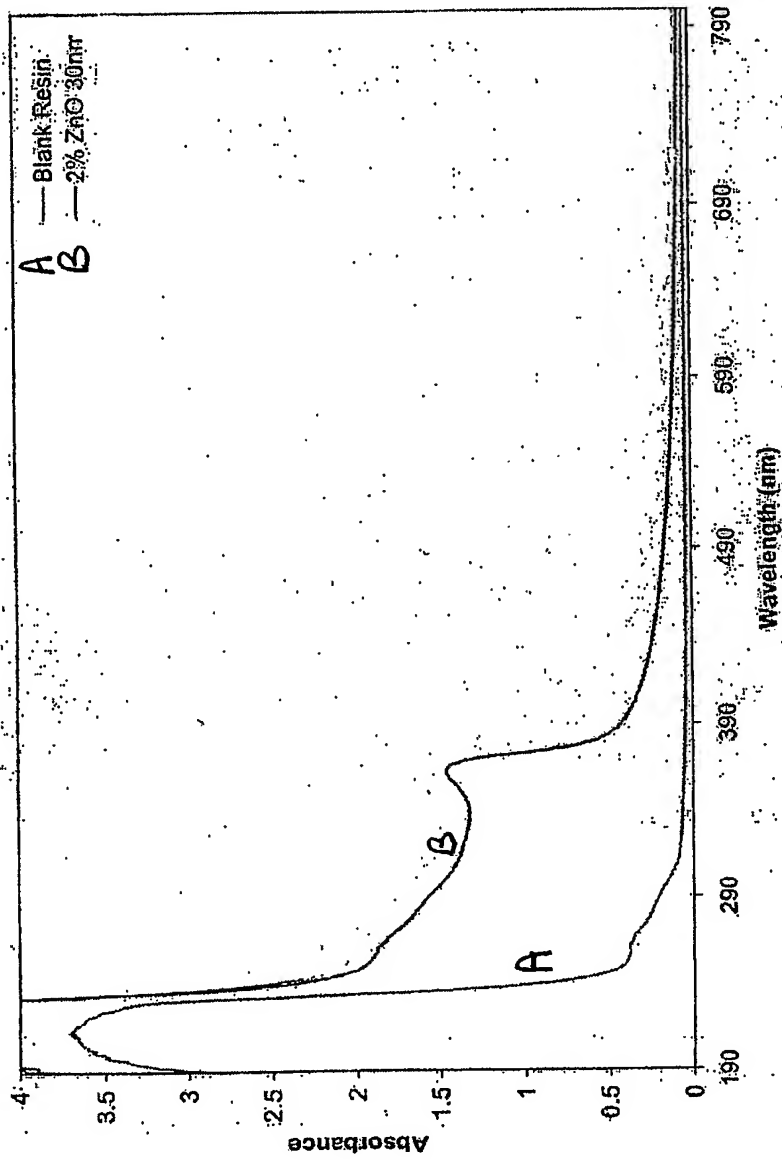


Figure 1 UV-Visible Absorbance Profiles of Resin Samples with Dry Film thickness ~50µm

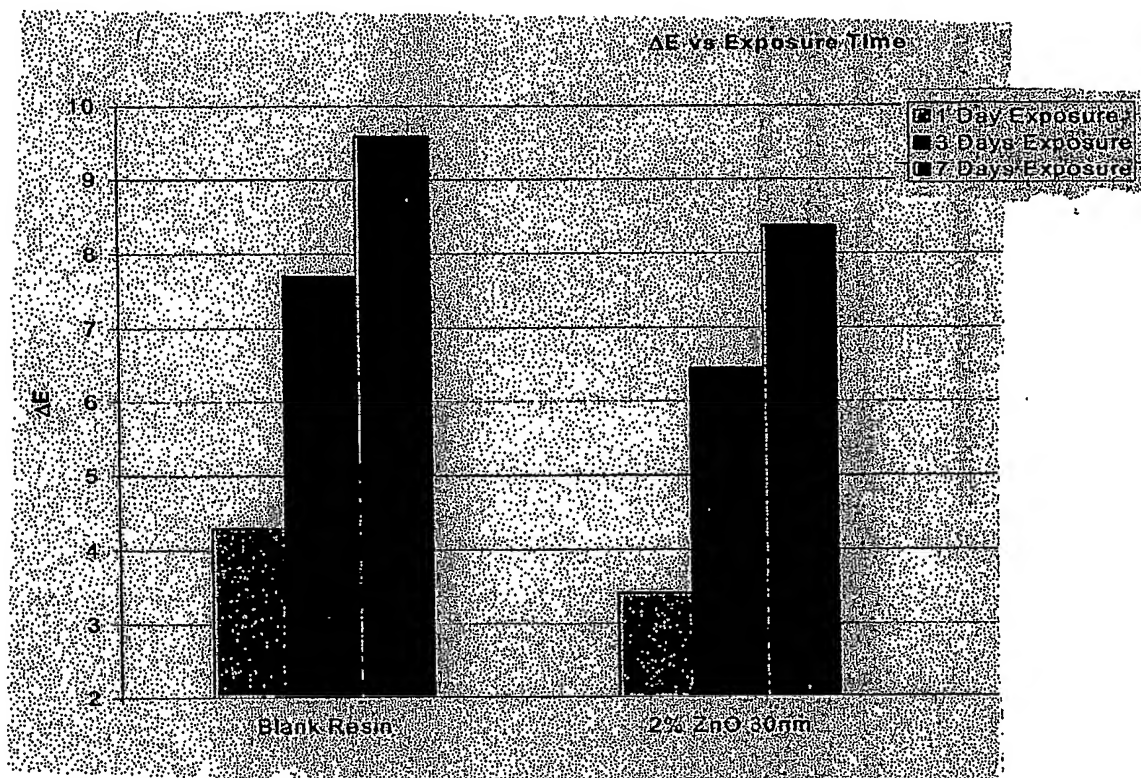


Figure 2: Colour Difference of Fabric Samples at Varying Days of UV Exposure

Absorbance of Different Additive Containing Resins

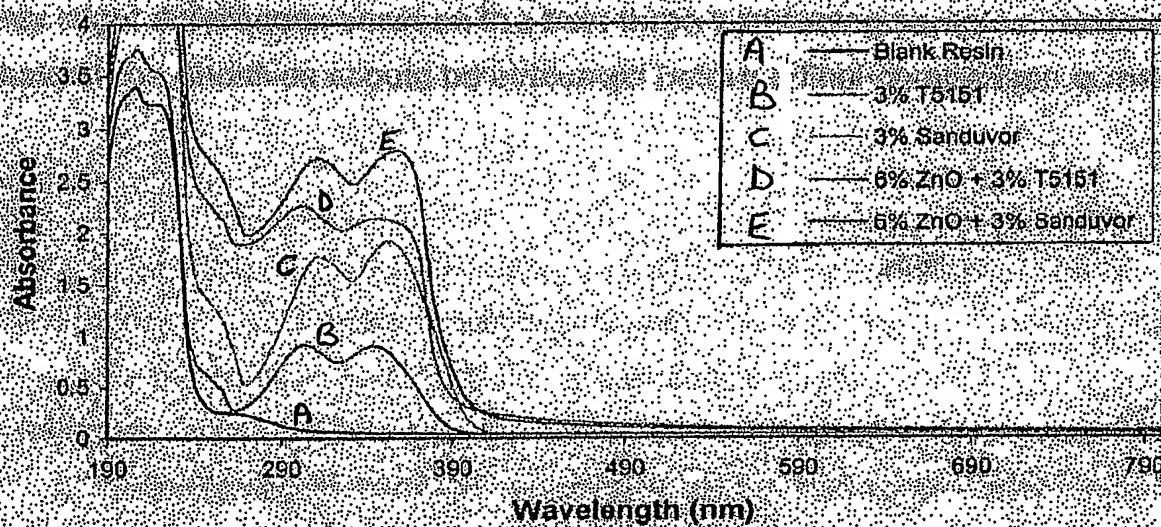


Figure 3 : Uv-Visible Absorbance Profiles of Resin Samples